July 19, 2010

Marlene H. Dortch
Secretary
Federal Communications Commission
445 Twelfth Street, S.W.
Washington, DC 20554

Re: WT Docket No. 06-150; PS Docket No. 06-229; GN Docket No. 09-51
Written *Ex Parte* Presentation

Dear Ms. Dortch:

The undersigned entities – Sprint Nextel Corporation, T-Mobile USA, Inc., United States Cellular Corporation, Clearwire Corporation, the Rural Cellular Association, the Rural Telecommunications Group, Inc., Access Spectrum, LLC and Xanadoo Company – strongly support the Commission's plan to move forward with an auction of the Upper 700 MHz D Block for commercial use as required by section 337(a)(2) of the Communications Act of 1934, as amended. The undersigned companies and organizations also support promoting interoperability across the entire 700 MHz Band to ensure the development of a multiband commercial and public safety device ecosystem. In addition, the undersigned support combining the Upper A and D Blocks to create a 2 x 6 MHz block, with appropriate compensation provided to incumbent A Block licensees. These steps will maximize the efficient use of this valuable spectrum, benefit consumers by promoting competitive entry into the 700 MHz Band, and promote the Commission's plan to establish a nationwide, interoperable public safety broadband network.

The Federal Communications Commission's interoperable broadband plan for public safety users can deliver more capacity in less spectrum than the high-site, high-power deployment scheme proposed by vendors of high-site, high-power communications equipment. In various submissions in these proceedings, Motorola has raised technical concerns about the Commission's plan to rely on modern, low-site, low-power commercial broadband network systems to support mission-critical communications.[1] None of Motorola's claims withstand scrutiny. As explained in the attached *700 MHz Upper Band Analysis* prepared by Doug Hyslop and Chris Helzer of Wireless Strategy, LLC, the Commission's plan, including the auction of the D Block for commercial use, will meet public safety capacity and priority access needs without creating harmful interference among the commercial and public safety users of the Upper 700 MHz Band. Motorola's claims to the contrary are based on flawed assumptions that would relegate public safety systems to outdated, costly, and spectrally inefficient network deployments that have no place in a broadband world.

In particular, the attached Wireless Strategy analysis demonstrates the following:

- ***Public Safety Capacity.*** Contrary to Motorola's claims that reallocation of the D Block to public safety is needed to meet public safety capacity needs, section II of the Wireless Strategy analysis shows that the existing allocation of 10 MHz of public safety broadband spectrum is more than sufficient to meet public safety capacity needs. Motorola's claims assume that the public safety broadband network will use a high-site, noise-limited network deployment. Such an assumption is based on deployment practices for first and second generation technologies which simply are not practical for 4G technologies like LTE that use the full wideband channel in each cell. By deploying 4G technology using a low-site, cellular-like approach, a public safety system using the existing 2x5 MHz public safety broadband spectrum allocation would provide greater system capacity using half the amount of spectrum compared to a high-site deploying using 2x10 MHz of spectrum. A cellular-like deployment will also provide more robust signal coverage and network redundancy, avoiding the dead spots, coverage holes, and intra-system interference that tends to plague high-site systems. Moreover, the Wireless Strategy analysis, as well as the FCC's OBI Technical Paper No. 2, demonstrate that a cellular-like deployment that leverages commercial technologies and infrastructure will be significantly less costly that a stand-alone, high-site public safety broadband network.

- ***Priority Access.*** Contrary to Motorola's claims, under the Commission's plan public safety users will have the priority access and quality of service they need for mission-critical communications in emergencies. As explained in section III of the Wireless Strategy analysis, public safety users will have access to their own RF access channel which will ensure entry into the network regardless of the amount of commercial traffic in a shared public-private network deployment. After gaining entry into the system, the public safety emergency communications will be assigned prioritization levels and quality of service to ensure prompt and effective public safety communications during emergencies. As described above, a cellular-like public safety deployment will enhance system capacity, including during emergencies. In addition, the Upper 700 MHz device

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[1] *See, e.g.,* Letter to Marlene H. Dortch, Secretary, Federal Communications Commission from Robert D. Kubik, Ph.D., Director, Telecom Relations Global, Motorola, Inc., PS Docket No. 06-229; WT Docket No. 06-150 (July 2, 2010); *see also* Letter to Marlene H. Dortch, Secretary, Federal Communications Commission from Steve B. Sharkey, Senior Director, Regulatory and Spectrum Policy, Motorola, Inc., PS Docket No. 06-229; WT Docket No. 06-150 (April 12, 2010).

band class proposed by the Coalition for 4G in America will facilitate public safety roaming onto the D Block and other commercial 700 MHz networks, providing even greater system capacity for public safety users during emergencies. The current Band Class 14, which Motorola supports, would isolate the D and public safety broadband blocks, inhibiting public safety roaming and also significantly increasing the cost of public safety devices.

- ***Interference Issues.*** Motorola has raised a number of interference claims in opposing an auction of the D Block for commercial use. These arguments similarly are based on outmoded deployment scenarios that are inconsistent with 4G technologies. By deploying a cellular-like architecture, public safety broadband systems can coexist with commercial systems on the D Block without harmful interference between systems and without the need for the 2 MHz guard band proposed by Motorola.

The Commission should reject Motorola's flawed technical claims. These claims provide no basis for reallocating the D Block to public safety or for delaying the auction of the D Block. The undersigned entities urge the Commission to expedite its pending rulemaking proceeding concerning the D Block so that this highly valuable spectrum can be auctioned for commercial use by the beginning of next year.

Respectfully submitted,

/s/ Lawrence R. Krevor
Lawrence R. Krevor
Vice President, Spectrum
Sprint Nextel Corporation
900 7th Street, NW, Suite 700
Washington, DC 20001

/s/ Thomas J. Sugrue
Vice President Government Affairs
T-Mobile USA, Inc.
401 9th Street, NW
Suite 550
Washington, DC 20004

/s/ Grant B. Spellmeyer
Grant B. Spellmeyer
Senior Director – Legislative and Regulatory Affairs
United States Cellular Corporation
8410 W. Bryn Mawr Ave.
Chicago, IL 60631

/s/ Chris Murray
Chris Murray
Vice President – External Affairs
Clearwire Corporation
815 Connecticut Ave., N.W.
Washington, DC 20006

/s/ Steven K. Berry
Steven K. Berry
President & CEO
Rural Cellular Association
805 15th Street, N.W., Suite 610
Washington, DC 20005

/s/ Caressa D. Bennet
Caressa D. Bennet
General Counsel
Rural Telecommunications Group, Inc.
10 G Street, NE, Suite 710
Washington, DC 20002

/s/ Michael I. Gottdenker
Michael I. Gottdenker
Chairman and CEO
Access Spectrum, LLC
3 Bethesda Metro Center, Suite 500
Bethesda, MD 20814

/s/ Marshall W. Pagon
Marshall W. Pagon
Chairman and CEO
Xanadoo Company
225 City Avenue, Suite 200
Bala Cynwyd, PA 19004

cc: James A. Barnett, Jr.
Stuart Benjamin
Jeff Cohen
Paul de Sa
Monica Desai
David Furth
Angela Giancarlo
John Giusti
Nese Guendelsberger
Bruce Liang Gottlieb
Evan R. Kwerel
John Leibovitz
Jennifer Manner
Charles Mathis
Ruth Milkman
Paul Murray
Louis Peraertz
Susan Singer
James Schlichting
Walter Strack
Joel Taubenblatt
Peter Trachtenberg
Margaret Wiener
Jeff Goldthorp
Julius Knapp
Tom Peters
Nicole McGinnis

700 MHz Upper Band Analysis

July 19, 2010

the business of wireless technology

Doug Hyslop
Chris Helzer

Wireless Strategy, LLC
PO Box 3353
Reston, VA 20195

www.wirelessstrategy.com

Table of Contents

I. Introduction

The Federal Communications Commission's interoperable broadband plan for public safety users can deliver more capacity using less spectrum than the high-site, high-power deployment scheme proposed by Motorola while supporting mission-critical priority access communications. Motorola has presented several claims to support its contention that the upper 700 MHz D block should be combined with the PSBB block to provide a 10+10 MHz allocation for Public Safety broadband services.[1] Motorola's claims are as follows: (1) 10+10 MHz is intrinsically better than 5+5 MHz to satisfy Public Safety's capacity requirements; (2) at least a 10+10 MHz configuration for a public safety system is required to support mission-critical priority access/pre-emption capabilities; (3) interference may result if the D Block is auctioned without sufficient guard band to Public Safety Broadband (PSBB) spectrum; and (4) the frequency harmonics of D Block frequencies may interfere with commercial device GPS reception.

None of Motorola's contentions regarding commercial auction of the upper D block withstand scrutiny. Thorough analysis of the above concerns indicates that multiple solutions are available to address the issues. Although Motorola poses one set of solutions geared towards a Public Safety high-site, standalone deployment approach, a second set of solutions is equally if not more feasible for the case where the 700 MHz D Block is commercially auctioned and the PSBB spectrum is used in a compatible, low-site deployment approach in collaboration with commercial wireless operators. Technical analyses supporting allocation of the 700 MHz D block commercially, while meeting the needs of Public Safety (PS), are provided below.[2]

First, we demonstrate that the coverage and capacity of a cellular-like deployment for the PSBB wireless system will exceed that of a high-site, standalone deployment, and do so with a lower cost.

Second, we note that the separate 5+5 MHz carrier for PSBB will provide the priority access and quality of service required by the mission-critical nature of Public Safety communications.

Third, assuming the PSBB spectrum is deployed using a cellular-like architecture, then the site density and system geometry will be similar to that of the commercial 700 MHz systems and will not experience the near-far interference issues which a high-site deployment encounters. Further, the upper 700 MHz C block, upper 700 MHz D block, and 700 MHz PSBB broadband systems will satisfy the FCC

[1] Motorola, Inc., Notice of Ex Parte Presentation, WT Docket 06-150 and PS Docket 06-229 (April 12, 2010) ("*Motorola April 12 Ex Parte*").

[2] Under 47 U.S.C. § 337(a)(2), the FCC is required to auction the D Block for commercial use. As described in our May 2010 analysis, the Coalition for 4G in America has proposed that the Upper A Block spectrum be combined with the D Block to create a 2 x 6 MHz block, with appropriate compensation provided to incumbent A Block licensees.

protection criteria to the Public Safety Narrowband (PSNB)[3] spectrum. Moreover, the 700 MHz D block 5 MHz carrier produces second harmonics in a manner that is essentially unchanged from the existing upper C block situation and the Motorola-proposed 10+10 MHz PSBB carrier. This fact negates the argument that the D block is unsuitable for commercial operation because of the production of a second harmonic interfering with GPS reception.

Finally, further information on duplexer design is provided to buttress the assertions in the first Wireless Strategy paper that a common duplexer for the 700 MHz Upper Band is not only feasible, but also readily available.

II. Public Safety Capacity

Motorola compares the capacity of a Public Safety deployment using 10+10 MHz of spectrum to one with 5+5 MHz of spectrum and claims that some emergency situations will require more capacity than is available in the 5 MHz approach. However, when comparing different deployment models such as a high-site system to a low-site system, the overall system capacity within a given geography should be compared.

From the interference section of Motorola's analysis, Motorola provides simulations for the case where six Public Safety sites cover the same area as fourteen commercial D block sites.[4] The relative capacity provided by the standalone PS system using 10+10 MHz may be compared to the PS capacity which would be realized with a low-site deployment approach in which the PSBB 5+5 MHz carrier is deployed in an architecture similar to the commercial wireless systems. This comparison is provided in Table 1 below. The sector capacity in the table is as shown in the Motorola presentation, which states that a sector with 10+10 MHz would provide twice the downlink capacity and more than twice the uplink capacity of a sector with 5+5 MHz of spectrum.

The Motorola simulations greatly simplified the system configurations for the upper D and PSBB block base stations. The same antenna height and base station parameters are used for both systems. Motorola then examined the interference to PS devices resulting from PSBB cell sizes ranging from the commercial cell size of 500 meters up to the larger cell size of 866 meters. Motorola does not address how the coverage range increases from 500 to 866 meters without modifying the radiofrequency (RF) design parameters. The difference in coverage range between the two cell sizes is in excess of 8 dB. Presumably, Motorola's simulations allowed excessive coverage overlap in the 500 meter case in order to provide sufficient coverage at 866 meters as well. In an actual commercial system deployment, the RF

[3] Doug Hyslop & Chris Helzer, *Wireless Strategy 700 MHz Band Analysis,* 11 (May 6, 2010) ("*700 MHz Band Analysis*"), *available in* Coalition for 4G in America, Written Ex Parte Presentation, WT Docket No. 06-150; PS Docket No. 06-229; GN Docket No. 09-51; RM Docket No. 11592 (May 27, 2010).

[4] *Motorola April 12 Ex Parte at* 18-19.

design engineer would adjust physical configurations and site parameters to provide the targeted signal level at the cell edge, not exceed the target by 8 dB. Excessive coverage overlap reduces system capacity through the excessive intra-system interference generated by the overlap. If the 500 meter commercial system in the simulation were designed properly, then the PSBB system with the 866 meter cell sizes would have required more than triple the tower height of the commercial base stations to achieve the same cell edge signal level. Therefore, Motorola is assuming a high-site system for the public safety wireless broadband deployment.

	High Site	**Cellular-like**	**Units**
# Sites	6	14	Number
Spectrum	10+10	5+5	MHz
DL Capacity/Sector	16.7	8.4	Mbps
UL Capacity/Sector	8	3.5	Mbps
DL System Capacity	**300.6**	**352.8**	Mbps
UL System Capacity	**144**	**147**	Mbps

Table 1: PSBB Capacity Comparison of High Site and Cellular-like Deployment Approaches

Note that the cellular-like approach, which uses only half of the spectrum of the high-site approach, provides greater system capacity for the Public Safety users. The coverage provided by the cellular-like approach would also be more robust, as shown in Figure 1, because more towers provide better in-vehicle and in-building signal penetration, improving coverage reliability.

Figure 1: Cellular-like System Design

A typical high-site design as overlaid on a cellular-like design is shown in Figure 2 below. A high site design increases the spacing between towers, which also increases the likelihood of trees, buildings, and terrain obscuring the signal. Dead spots or coverage holes are typically larger in a high-site system than in a cellular-like system.

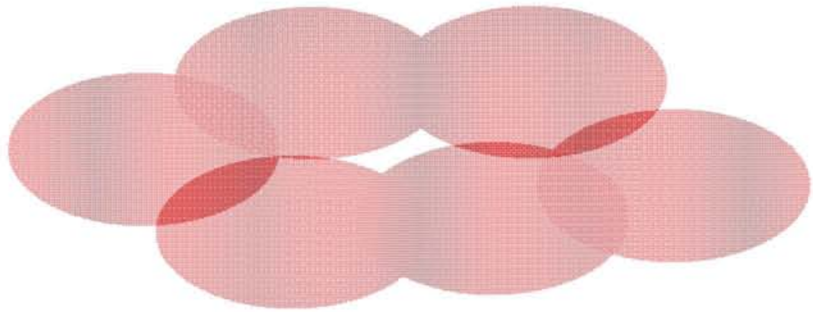

Figure 2: High Site System Comparison to Cellular-like System

A further observation on relative system capacity may be made. As noted above, Motorola makes an assumption that the system capacity scales the same as, or greater than, the amount of spectrum used at the site, which implies that Motorola uses similar intra-system interference for the two deployment models. Site capacity depends on the level of intra-system interference, which is a function of the system geometry[5]. As a general rule, high sites with a large distance between base stations will offer less per-site capacity than lower sites with smaller inter-site distances. The high site design uses towers with taller radiation centers and less antenna downtilt to extend the coverage range. Antenna downtilt is the wireless engineering practice of adjusting the antenna beam such that the main antenna gain is focused below the horizon, increasing signal strength within the coverage area and reducing interfering signals to the surrounding cells as shown in Figure 3.

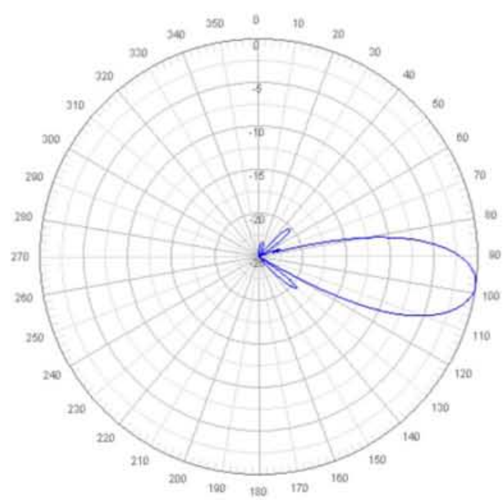

Figure 3: Antenna Pattern with Cellular-like Antenna Downtilt

[5] System geometry refers to the overall system configuration in terms of tower height, antenna pattern and tilt, etc.

The high site antenna beams will be focused toward the horizon to maximize coverage range, as shown in Figure 4, with the side-effect that the signals will travel farther beyond the cell boundary, creating interference to the neighboring sites. With narrowband voice systems, as in public safety trunked radio, interference among sites is significantly reduced by using different frequencies at each high site. Thus, the coverage from each narrowband site location may be maximized without affecting reception in the surrounding sites, as illustrated in Figure 5. Co-channel frequency assignments, represented by the same color cell area, are only typically made between sites which are separated by a large geographic distance, or by signal-blocking terrain. This high-site, noise-limited system design is well-suited for Public Safety's current narrowband voice systems, but is not practical for a wireless broadband technology like LTE which uses the full wideband channel in every cell.

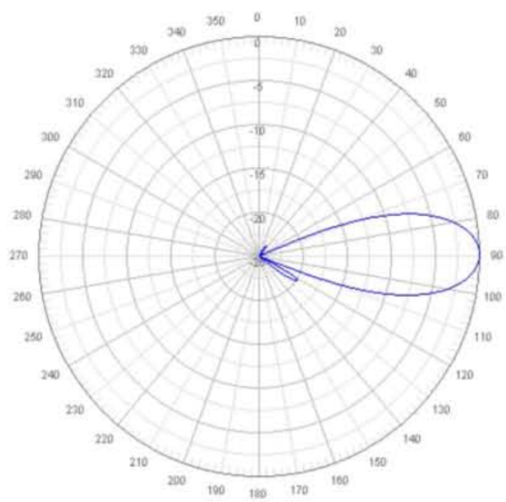

Figure 4: Antenna Pattern without Antenna Downtilt

Figure 5: High Site Narrowband System Frequency Reuse

A high-site system using LTE would create considerable intra-system interference, reducing the sector capacity relative to that of a cellular-like site. Moreover, the achievable user data rate at a given location depends on the signal quality. If an incident occurs far from a high site PS tower location, then the intra-system interference will greatly reduce the signal-to-noise ratio (SNR) received at that location, and the throughput will be significantly reduced. With a cellular-like system, a larger percentage of the coverage area will receive favorable SNR levels capable of supporting several simultaneous high-quality video streams.[6] Therefore, the Motorola analysis provides optimistic estimates of high site system capacity, ignoring the impacts from the large cell areas and increased intra-system interference. Regardless, we used the optimistic Motorola capacity numbers in the above comparison, and still demonstrated greater capacity for the cellular-like system deployment. A more realistic approach to capacity estimation would considerably widen the capacity gap in favor of the low-site system deployment.

Of course, given limited funding, the cellular-like approach would only make sense if the costs are on par with that of a high-site approach. The cellular-like approach requires more PSBB-enabled sites to cover a given area. The Commission has developed cost estimates[7] for a standalone Public Safety wireless broadband deployment and for a shared deployment approach with other commercial operators. The Commission correctly assumes the same number of sites in both approaches to ensure the delivery of similar coverage and capacity. As noted above, the high-site approach would yield less favorable network performance than the cellular-like approach.

If, for the moment, we ignore the less favorable high site network performance and directly compare the deployment cost of the high site and cellular-like approaches, the cellular-like approach still delivers a lower cost of system deployment. As explained in the OBI Technical Paper No. 2, the cost of deploying a "ruggedized" public safety broadband network is greatly reduced if, instead of deploying a standalone network, public safety leverages commercial technologies and infrastructure. Table 2 illustrates the significant capital expense advantage offered by the cellular-like approach over the high-site approach. This analysis once again builds upon the system metrics illustrated by Motorola of six and fourteen sites for deployment models.

	Standalone Network	**Cellular-like Shared Network**
# Sites	6	14
Capital Expense/Site	$ 273,752	$ 95,000
System Cost	**$ 1,642,512**	**$ 1,330,000**

[6] The precise percentage of the coverage area receiving more favorable RF conditions requires detailed system simulations, dependent on numerous input assumptions such as vendor equipment specifications, proprietary vendor algorithms, physical site parameters, and RF design assumptions such as coverage area reliability, interference margin, device capabilities, etc. Motorola acknowledges the shortcomings in its simulation methodology which over-simplifies its projected network performance. *Motorola April 12 Ex Parte* at 21.

[7] OBI Technical Paper No. 2, "A Broadband Network Cost Model: A Basis for Public Funding Essential to Bringing Nationwide Interoperable Communications to America's First Responders", May 2010. The standalone Public Safety capital expense above reflects the blended cost of existing versus new tower builds as assumed in the OBI paper. The shared network cost is also as provided in Exhibit 6 of the paper.

Table 2: Shared versus Standalone Cost Comparison

Thus, even with the unrealistic assumption of a smaller number of towers for the standalone approach, the overall capital expenses are higher. The delta in network cost becomes significantly larger, as demonstrated in the OBI paper, when a similar number of sites are assumed for both deployment approaches.

In summary, a cellular-like deployment of 5+5 MHz of PSBB spectrum would deliver greater system capacity at a lower cost than a high site 10+10 MHz deployment. Furthermore, during emergencies, first responders may leverage the commercial LTE systems as needed, significantly exceeding the capacity of a standalone PSBB system.

III. Public Safety System Access

Motorola is correct in stating that Public Safety must gain access to wireless communications regardless of the circumstances. Public Safety communications requires non-contentious access to enter into the wireless system, prioritization by user and type of traffic during network resource setup to support the request, and quality of service to maintain the proper treatment throughout the data session. A significant amount of capacity must be dedicated for Public Safety use, with access to overflow capacity in an emergency. All of these capabilities are supported in the case where the PSBB 5+5 MHz system is deployed in a cellular-like configuration and the upper D block is commercially auctioned.

First, Public Safety devices will be guaranteed entry into the wireless system. When a subscriber device attempts to place a telephone call or data session, the request is made over a portion of the wireless uplink channel called the access channel. This access channel is available to all subscriber devices capable of accessing the operator’s system. During normal system operation, the arrival probability of new call requests is such that the access channel can process the requests with little likelihood that the requests would arrive at the same time and interfere with each other. When multiple requests do arrive at the same time, retry mechanisms enable the devices to space their subsequent requests over time to allow all devices to successfully access the system and place their telephone calls.

In times of major crisis, the commercial networks often become overloaded by customers all requesting permission to place calls simultaneously. Although each wireless technology has built-in mechanisms for controlling this extreme case, the access channel is open to all users. Under the unusually heavy call request load of a crisis, numerous requests arrive simultaneously with many requests colliding. Some customers are unable to access the system in these extreme cases. When the access channel to enter the commercial system is overloaded, then priority for mission-critical users is difficult to maintain.

In a shared deployment approach, the commercial channel and the PSBB LTE channel would be configured as separate RF carriers as illustrated in Figure 6. LTE is capable of managing device access to different wireless channels, and base station scheduling may flexibly balance traffic among multiple channels. In the event of a crisis, the PSBB access channel would be available to process the public safety device access requests, regardless of the call request load on the commercial blocks.

Figure 6: Commercial Access Channel Contention and Clear PSBB Channel

Figure 6 is provided for illustrative purposes. In an actual crisis, the commercial access channel could be inundated with requests from hundreds of devices per sector, versus tens of devices for the Public Safety access channel. The number of calls is considerably lower for the PSBB channel, ensuring successful system entry for all first responders.

After gaining entry to the system, the second requirement is to accurately prioritize the system resources to the most urgent communications need. LTE supports multiple prioritization levels by user and by type of traffic, to ensure, for example, that the fire chief's video session goes through and the e-mail upload for a non-mission critical support member is either throttled or queued if necessary. Quality of service aspects are assigned to every data session, ensuring that the session's latency and throughput requirements are met and higher-priority sessions are accorded greater bandwidth than lower-priority sessions.

Finally, the cellular-like use of the 5+5 MHz PSBB channel provides greater capacity than a standalone, high site 10+10 MHz channel as demonstrated in section II. Furthermore, with the cellular-like approach, the public safety devices may leverage the commercial systems' capacity during emergencies, greatly surpassing the capacity which would be available with a 10 MHz high-site system. This capability to roam onto the commercial 700 MHz systems for coverage and, when needed, emergency capacity, is feasible with the New Upper Band, which encompasses both the upper C and D blocks within the same duplexer as the PSBB block.[8] To the extent desired by Public Safety, a tight level

[8] *See 700 MHz Band Analysis* at 10-11 (identifying New Upper Band and discussing its efficiencies).

of integration with the commercial networks may be achieved, seamlessly handing over PSBB sessions to the commercial systems as dictated by the emergency.

In contrast, the Motorola plan isolates the upper D and PSBB blocks into Band 14, which would require a specially designed duplexer unique to the Public Safety community. Few device manufacturers would support this band given the low handset volume per year, driving up the cost of handsets. Public safety roaming onto other 700 MHz spectrum blocks, or other spectrum bands, would require the integration of additional parts in the Public Safety device. Such an approach requires multi-band scanning and processing to detect the other networks, with a significant reduction in battery life and increased risk of handover failures and dropped calls.

IV. Interference Potential

In the 700 MHz band, the upper C device transmit block edge (776-787 MHz) is 1 MHz away from the PSNB device receive block (769-775 MHz). The 3GPP specification excludes the 776-777 MHz portion of the C block from the band 13 definition to provide 2 MHz of separation from PSNB. With respect to device-to-device interference, the Upper C block is closest to the PSNB device receive block, and interference considerations for both the Band 13 and New Upper Band duplexers will be similar. Use of the upper D and PSBB blocks will not significantly affect this boundary, since their transmissions are farther from the PSNB device receive block.

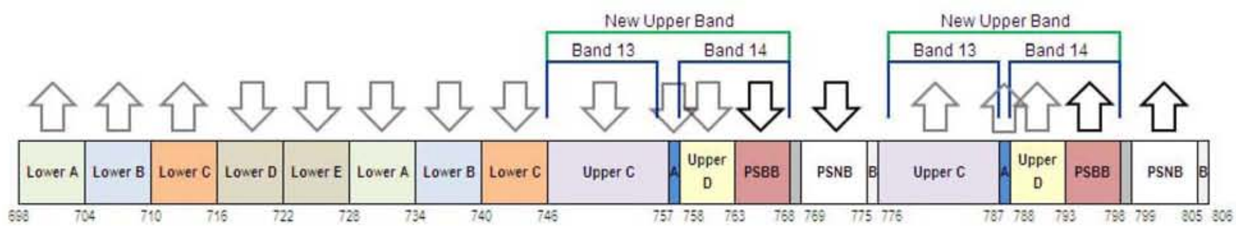

Figure 7: 700 MHz Upper Band

With respect to base station to device interference, the boundary between the Upper D block and the PSBB spectrum becomes important. Motorola states that interference may result if the D Block is auctioned without sufficient guard band from the PSBB.[9] This statement hinges on the assumption that the PSBB system is a high site system. In the high site approach, a relatively small number of PS towers are built to cover an area. The high site design will inevitably have boundary areas between sites where the desired signal is weak. If an upper C or D block base station is located within the weak coverage zone, and the Public Safety device does not have sufficient filtering or isolation, then the PS device may experience interference from the commercial base station, as illustrated in Figure 8, where the distant but weak PS signal is shown by the dotted green line and the commercial interfering base station signal is shown by the black arrow. Motorola states that a 2 MHz guard band is sufficient to reduce interference from commercial base stations to PSBB devices.[10]

[9] *Motorola April 12 Ex Parte* at 27.

[10] *Id*. at 27.

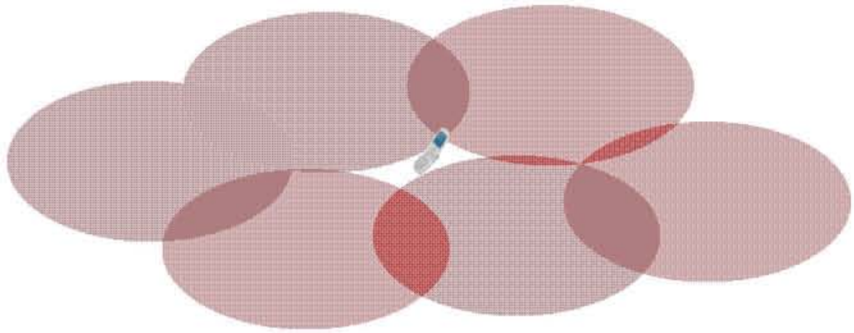

Figure 8: PS Device Near-Far Interference in a High Site Design

In the cellular-like approach, the system deployment resembles that of commercial systems today. In 3G and 4G commercial systems, intra-system interference from many sites using the same operating frequency introduces a noise rise to the system, meaning that the minimum signal which may be received by the device is degraded by several dB from the interference. Intra-system interference is a common concept to all frequency reuse-of-one technologies, including LTE. The resulting coverage reduction from this interference is accounted for in the RF design process by inclusion of an interference margin. Combined with receiver blocking specifications and typical distance separations from neighboring base stations, the devices operating on the cellular system travel throughout the coverage area without degradation from the adjacent channel base station transmissions. This deployment scenario is identical to the multiple operators co-existing in PCS and AWS bands, where the block allocations are immediately adjacent. With a cellular-like deployment for the PSBB spectrum, a separate guard band is not required between the D block and the PSBB block.

To close out the discussion of 700 MHz interference, Figure 9 demonstrates the similarity of the New Upper Band duplexer filter to the Band 13 duplexer filter with respect to mobile emissions into the PSNB spectrum, as simulated by Avago Technologies. Avago Technologies is one of the leading suppliers of interface components for communications, industrial and consumer applications, and one of the world's leading manufacturers of device duplexers. Both filters in the Avago Technologies' simulation attenuate in the first few megahertz of the PSNB spectrum, but not enough to contribute to the 65 + 10 log P requirement applicable to the entire PSNB block. Therefore, the FCC rules regarding OOBE into the PSNB spectrum are met through the LTE emissions mask[11], which applies equally well to any of the commercial blocks. In other words, based on the Avago Technologies simulation, the OOBE performance of a duplexer for the proposed New Upper Band is substantially the same as a duplexer for Band 13: neither duplexer provides adequate OOBE. The Commission's OOBE rules are met, however,

[11] Table 6.6.2.2.3-1: Additional requirements, signaled value NS-06. 3GPP TS 36.101 v8.9.0 (2010-03).

through the design of the mobile transmit chain to adhere to the 3GPP LTE emissions mask. The Band 13 duplexer filtering is not a prerequisite to compliance with the FCC OOBE rules.

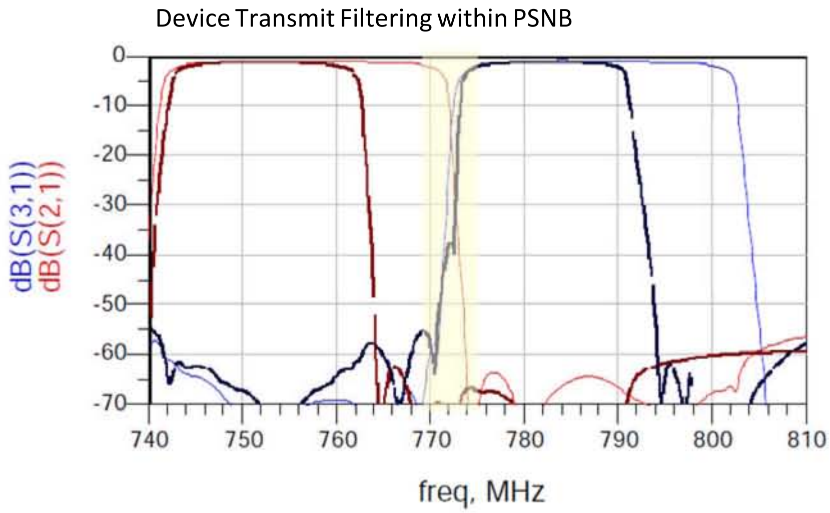

Figure 9: Avago Band 13 and Upper Band Duplexer Simulations
(Emphasis added by Wireless Strategy)

V. Harmonics

The GPS signal is a CDMA signal centered at 1575.42 MHz. A portion of the 700 MHz upper band has the potential of creating a second harmonic which would fall within the GPS receive channel. The 700 MHz frequencies potentially causing the harmonic are 787.21 MHz to 788.21 MHz. Motorola proposes combination of the D block with PSBB to create a 10 MHz carrier with a carrier separation distance of 290 kHz[12] from the edge of the interference zone at 788.21 MHz.

The Verizon Wireless upper C block carrier is adjacent to the lower edge of the harmonic generation region, with a carrier separation of 710 kHz.

The D block, as currently allocated and with a 5 MHz LTE carrier, would have 40 kHz of separation from the harmonic region.

From the 3GPP emissions mask[13], we may calculate the relative emissions within the harmonic region to assess likely impact of a commercial D block approach versus the current upper C block approach, and versus the proposed Motorola PS 10 MHz plan.

[12] *Motorola April 12 Ex Parte* at 26.

[13] 3GPP, *Evolved Universal Terrestrial Radio Access (E-UTRA); User Equipment (UE) Radio Transmission and Reception*, 3GPP TS 36.101.

	Commercial D Block	Upper C Block	Motorola PS Plan
Carrier Bandwidth (MHz)	5	10	10
Frequency Separation (kHz)	40	710	290
Emissions Mask (dBm)	0.2	-3	-3

Table 3: Signal Comparison in GPS Harmonics Region

None of the three LTE channels would actively transmit within the portion of the 700 MHz band where harmonic generation would fall within the GPS receiver channel. All three channels show a significant reduction in the emissions relative to the in-band power of the LTE device transmit signal. With a delta of only 3.2 dB among the power levels reaching the edge of the 700 MHz harmonic region, the Motorola proposal offers no significant advantage over the commercial D block use of the spectrum with respect to harmonic interference reduction. Furthermore, the frequency separations listed in Table 3 are insufficient for any filter to deliver direct attenuation to the 787.21-788.21 MHz spectrum.

Rather, the harmonics issue is addressed through transmit filtering within the duplexer to "notch out" the GPS frequency directly. Routine transmit filtering would sufficiently reduce any second harmonic signals produced by the transmitter to protect GPS reception within the device. This approach equally solves the harmonics issue for the upper C block, the upper D block, and the PSBB block. An illustration of second harmonic transmitter filtering within the duplexer is shown in Figure 10 below. The figure contains the simulation results developed by Avago Technologies for Band 13 (black line) and the New Upper Band as proposed in the May 2010 Wireless Strategy paper (blue line in the figure), with focus on the GPS receiver frequency centered at 1575.42 MHz. As may be seen from the figure, both transmitter filter curves provide significant rejection of the second harmonic frequency.

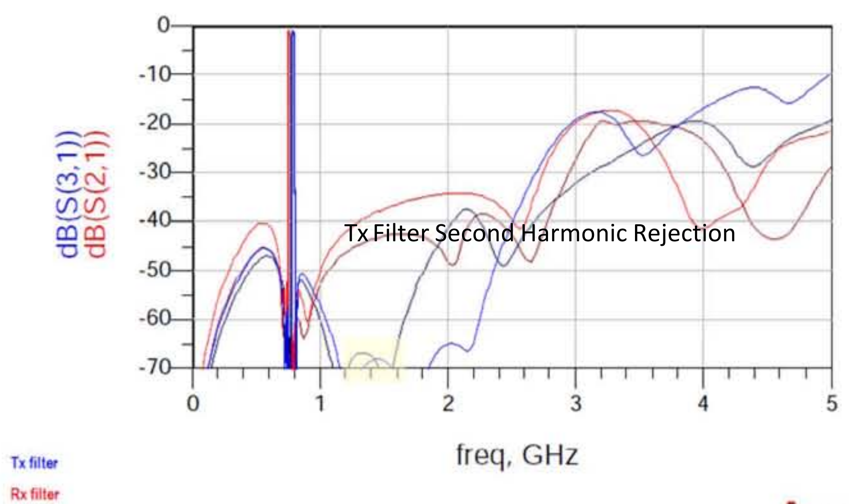

Figure 10: Avago Band 13 and Upper Band Tx Filter Curves
(emphasis added by Wireless Strategy)

VI. Commercial Duplexer Design

As noted in the May 2010 Wireless Strategy paper, commercial Film Bulk Acoustic Resonator (FBAR) duplexer filters built for other spectrum bands with similar transmit/receive characteristics as the US 700 MHz band are commercially viable. Subsequent to that filing, Avago Technologies provided the Coalition members with simulation results for FBAR duplexers for both the Band 13 frequencies and the proposed New Upper Band described in the Wireless Strategy paper.

Figure 12 provides the device transmit insertion loss comparison, and figure 13 shows the device receive insertion loss. The performance depicted for the two bands is similar, and on par with duplexer specifications for other 3GPP bands.

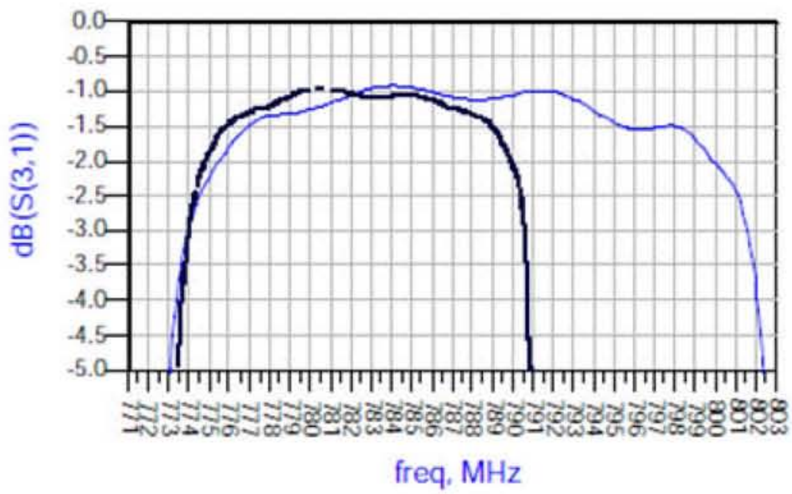

Figure 12: Avago Band 13 and Upper Band Transmit Insertion Loss

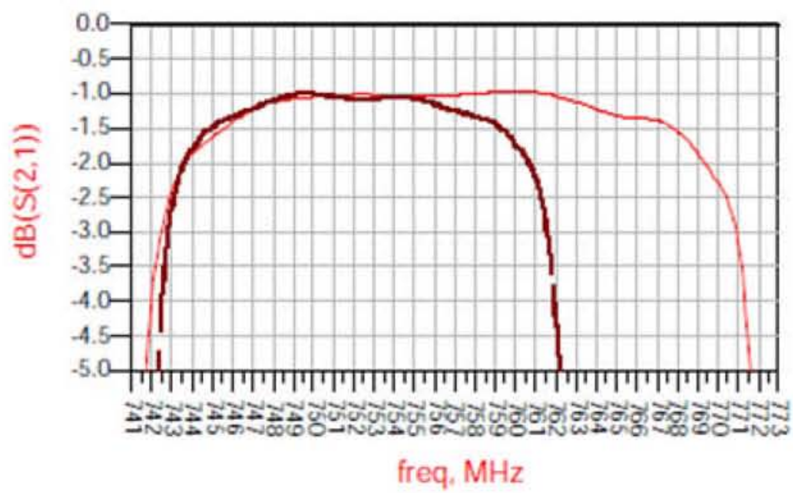

Figure 13: Avago Technologies Band 13 and Upper Band Receive Insertion Loss

Additional evidence of the feasibility of a New Upper Band duplexer may be found in the support of SAW filters for the 3GPP Band VIII. As noted in the May paper, 3GPP Band VIII supports UMTS in the 900 MHz band, with transmit-receive separation of 10 MHz and passbands of 35 MHz. We expect the 700 MHz Upper Band duplexer to perform better than a Band VIII duplexer given the more favorable passband size. In a 2008 article publicly available on the Internet[14], Fujitsu introduced support for a SAW filter for Band VIII with rejection and insertion loss figures typical of other bands. Based on Avago Technologies' side-by-side simulations of Band 13 and the New Upper Band, and the availability of SAW filter support for 3GPP band VIII since at least 2008, duplexer support for the New Upper Band is readily achievable with current filter technology.

VII. Conclusions

As demonstrated above, a cellular-like deployment for the Public Safety broadband system will provide greater capacity, improved coverage, and to the extent that a cellular-like shared-network deployment is followed, significantly lower costs than a high-site, standalone PS network approach. Through the cellular-like deployment approach, interference will resemble that typically planned within cellular systems and readily handled by the reuse-of-one technologies such as LTE. Indeed, by leveraging the New Upper Band, the Public Safety devices would support the upper C, upper D, and PSBB systems, significantly increasing the capacity, coverage, redundancy, and roaming opportunities available to the Public Safety organizations.

[14] Fujitsu, Ultra-Small SAW Duplexer for W-CDMA and Ultra-Small SAW Filter for GSM, (2008), *available at* http://www.fujitsu.com/downloads/EDG/binary/pdf/find/26-3e/8.pdf

About the Authors

Chris Helzer, Partner, Wireless Strategy, LLC
Chris has 18 years of technical leadership in wireless communications, product development, and software development. Prior to Wireless Strategy, Chris was the Director of Radio Access Network and Subscriber Unit Architecture at Nextel Communications. Earlier experience includes work as the product manager for a tool for monitoring and reporting the performance of wireless networks, an RF engineering consultant designing much of Nextel's iDEN network in California, and a software developer working on medical billing systems and custom database applications. Chris holds a B.S. in Electrical Engineering and a B.S. in Physics from the University of Maryland, College Park.

Doug Hyslop, Partner, Wireless Strategy, LLC
With 18 years of experience, Doug has led RF engineering teams for large markets, directed major technology development programs, and advised executives of the business impacts of wireless technology evolution. Prior to Wireless Strategy, Doug was the Director of Next Generation Access Technologies for Nextel and Sprint Nextel. Earlier experience includes the construction and launch of the first iDEN systems in California and Texas, RF capacity tool development and support, and management of iDEN base station evolution for Nextel. Doug holds a B.S. in Electrical Engineering from the University of Virginia.